

Making the best of a Human modified Habitat; an Assessment of Avian Distribution and Diversity in Federal College of Education (Technical) Gombe. Gombe State- Nigeria

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Abstract— We assessed the abundance and diversity of avian species in two distinct habitats types; main campus area (human inhabited) and adjoining heavily degraded savannah grassland. By employing Jaccard/Tanimoto Coefficient of Similarity, we tested whether bird species assemblage will differ between the two habitats, while Shannon Weiner Diversity Index was used to determine the level of diversity between sites.

Line transect assessment generated a total of 1035 individuals of 69 avian species from 53 genera and 32 families. The most diverse avian family was Estrildidae with nine (9) avian species, followed by Columbidae with six (6), while Falconidae, Nectriniidae, and Turdidae families had a record of four (4) species each. Five families (Ardeidae, Malaconotidae, Ploceidae, Silviidae, Sturnidae) and five families (Accipitridae, Bucerotidae, Capitonidae, Viduidae and Psittacidae) followed with three (3) and (2) species respectively. Seventeen (17) families were each represented by a single species.

Jaccard/Tanimoto Coefficient revealed that species composition differed between the two habitats with a similarity coefficient of 66.7 %, while Shannon Weiner Diversity Index was 1.56 and 1.67 for human inhabited (HI) and degraded savannah (DS) habitats respectively. The proximity to a natural savannah habitat albeit degraded has positive implications for avian diversity in the study area. We recommend more exclusion of human activities such as fuel wood harvesting and land grab for farming as this has grave consequences for the thriving population of species that are sensitive to human presence and urbanization.

Keywords— Avian species, Diversity, Habitat utilization, Disturbance. Abundance.

I. INTRODUCTION

One of the most outstanding features of birds is their high mobility and ability to travel great distances even across oceans (Borrow and Demey, 2001). Birds occur in all habitats known to man. (Mann and Cheke, 2001); the ubiquitous nature of birds and their sensitivity to ecosystem change makes them a very important component of biodiversity, and as such; birds are often used as good indicators of the state of health of the environment (Pearce and Ferrier, 2001; Gregory et al., 2003; Krisanti et al., 2017). Birds reflect changes in other biodiversity (example other animals and plants) and are highly responsive to environmental perturbations; making them very useful in studies designed to address the effects of human and other environmental disturbances on community stability and ecosystem productivity (Ezealor, 2002; Gregory et al., 2009). Birds contribute substantially to the overall species richness of West African forests, currently recognized as biodiversity hotspots of global importance (Orme et al., 2005).

Species diversity is a community attribute that is directly related to ecosystem productivity and vegetation structure (Tilman, 1996). Research has shown that species diversity is directly linked with habitat structure (James and Warner, 1982) as well as patterns of distribution of resources within a given ecological setting (Pringle et al., 2010).

The pattern and distribution of species has serious implication for community productivity. For instance, Pringle et al. (2010) proved that the regular (even spacing) spatial pattern of termite mounds found in a homogeneous African savannah provided a guide for parallel spatial patterning in tree-dwelling, termite-eating animal communities. Their findings, which also confirm that the uniformity of these patterns at small spatial scales boosted productivity of the whole landscape; provide support for

models linking spatial patterns with ecosystem processes and functioning (Mommott et al, 2004; Bakam et al., 2018).

In the same manner, we explored how habitat structure and resource availability in a human modified habitat will affect avian distribution, abundance and diversity (Odewumi et al., 2017). We tested whether species will partition resource use along a gradient of disturbance in the study area (Agbo et al., 2018). This was possible considering the fact that the campus is contiguous to a natural but patchy and degraded savannah landscape made of some remnant native tree species. Our experimental approach was guided by the fact that vegetation structure is the most proximate factor that determines the spatial distribution of species (James and Warner, 1982); and more specifically bird diversity, enhanced by the plant species composition (Manu et al., 2007; Manu et al., 2010).

The goal of this study was therefore to determine how well birds utilize human modified habitats as well as the factors that may be crucial for their persistence in this degraded landscape. Specific objectives were to;

- i. Develop a comprehensive checklist of the area.
- ii. Identify the most abundant species in the study area

- iii. Determine whether species composition (diversity) will differ between the two sites.

II. MATERIALS AND METHODS

2.1. Study Area

The study was conducted in The Federal College of Education (Technical Gombe), established in 1977. The college operated elsewhere for 17 years before moving to the present campus (permanent site) in 1996. The College is located along Ashaka road (Latitude $10^{\circ} 18'30''$ N, Longitude $11^{\circ} 9'30''$ E.) in Akko Local Government Area, Gombe.

The annual rainfall ranges from 850 to 1000 mm, with two distinct seasons; rainy and dry seasons. The rainy season starts from May to October and dry season from November to April. Average daily temperatures are 34° C in April and 27° C in August. The relative humidity ranges from 70 to 80 % in August and decreases to about 15 to 20 % in December.

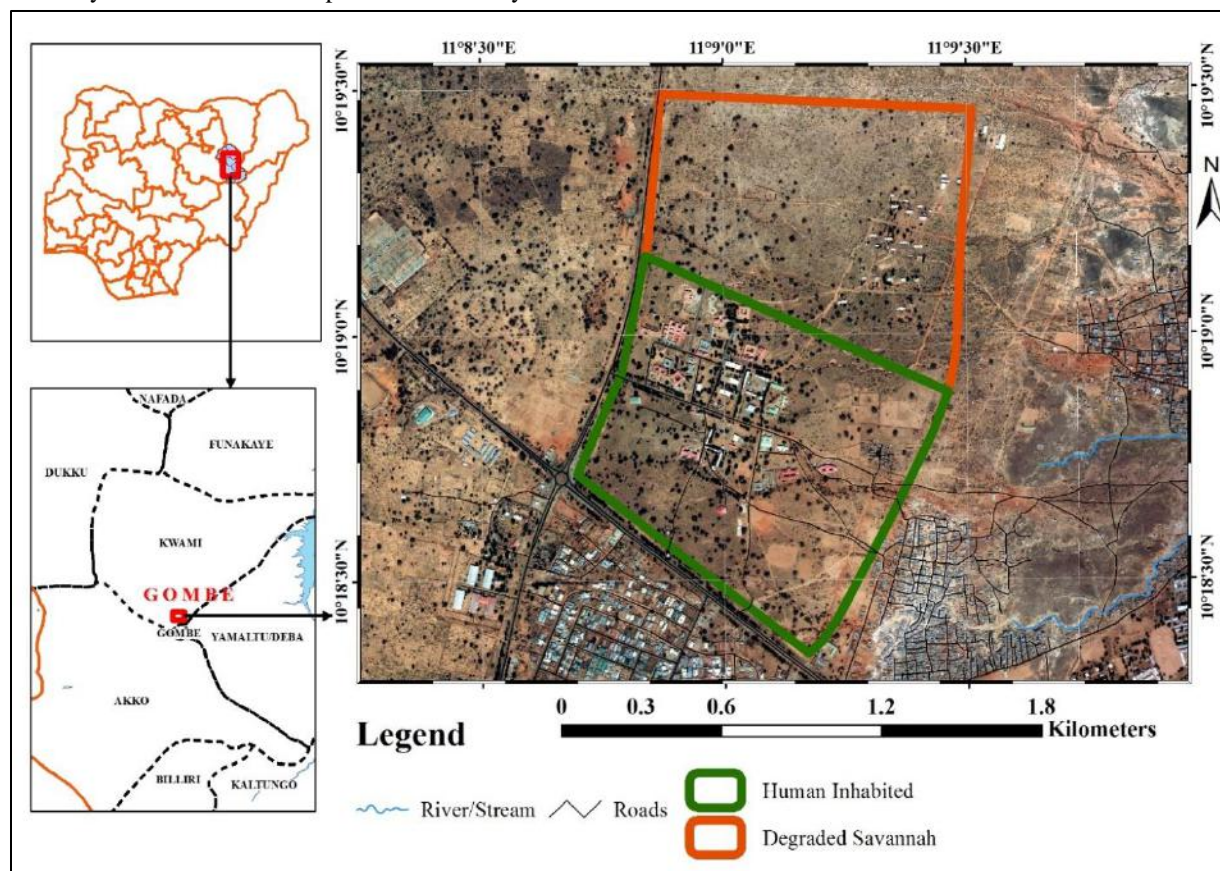


Fig.1: Map of study Area showing the two habitat types (human inhabited and degraded savannah).

The college lies within the Sudano–Sahelian Savannah vegetation typified by shrubs and sparsely distributed tree

species. Regrettably, as is typical with most human modified habitats, the campus flora is now dominated by exotic and

introduced tree species interspersed with a few remnant natives, the most prominent being *Parkia biglobosa* and *Tamarindus indica*. The college is divided into two unique habitats; the campus area hereinafter referred to as the human inhabited (HI) contiguous to a degraded savannah (DS) (Fig 1). The most common native tree species in the degraded savannah habitat was *Parkia biglobosa* while *Azadirachta indica* (Neem) was the most common tree species in the human occupied habitat.

2.2 Experimental Design

Line transect method (Bibby et al, 2000) was used to estimate and record bird species seen or heard within the study area. The campus was divided into two major habitat types; Degraded Savannah (DS) and Human inhabited (HI), with each habitat comprising of three transects. Each transect was located at a horizontal distance of 250 m apart to ensure that the same bird species was not recorded repeatedly in a given transect. Each transect covered a total distance of 2000 meters.

Transects were monitored twice each day in the morning and later in the evening. The morning session commenced at 6:30 am and lasted till about 9:30 am, while the evening sessions were conducted between the hours of 3:30 pm – 6:30 pm. During each transect survey we walked slowly along each transect and recorded bird species seen at least 50 m on either side of the transect or heard (Bibby et al, 2000). With the help of a pair of (Nikon sporter ® 8 x 42) binoculars we recorded the number seen and estimated the distance away from the transect. Each transect was repeated twice to optimize the record. The survey was conducted in 2016 during the end of the dry season and towards the onset of the rains.

Data generated from the survey was entered in excel spreadsheet version 2013 and explored before exporting same to SPSS. The statistical Package for Social Science (SPSS version 19.0 was used to analyze the data. Descriptive statistics was used to determine the frequency and numerical abundance of each avian species. Shannon Weiner Diversity index was employed to determine the species diversity and evenness in the study area and for each of the two habitats.

We calculated the level of similarity in species composition between the two habitats based on the Jaccard/Tanimoto Coefficient; which is one of the metrics deployed to compare the similarity and diversity of sample sets. It uses the ratio of the intersecting set to the union set as the measure of similarity or dissimilarity. Thus it equals to zero if there are no intersecting elements and equals to one if all elements intersect (common species to both sets). This was explored using the equation below;

$$T = \frac{N_c}{N_a + N_b - N_c} \quad \text{Equation 1}$$

where;

N_a - number of element in set A

N_b - number of elements in set B

N_c - number of elements in intersecting set

Shannon Wiener Diversity Index was used to estimate avian diversity of the study area. Effective number of species (Jost, 2006) was used to determine the pattern of distribution (even or uneven) of avian species. The closer the value of *Effective number* of species to the species richness (actual species count), the more even the distribution of the species and vice-versa.

Shannon Wiener Diversity Index was calculated using the formular below:

$$H' = -\sum_{i=1}^s p_i \log_e p_i$$

Equation 2

Where H' = Shannon Wiener Index

P_i = the proportion of individuals of species “i” in relation to the total population of all species.

\log_e = Natural logarithm of base e. To get the *effective number of species*, (the true value of diversity), we used the equation

$$\exp(H') \text{ or } \exp(-\sum_{i=1}^s p_i \log_e p_i) \quad \text{Equation 3}$$

III. RESULTS

A total of 1035 individuals of 69 avian species from 53 genera and 32 families were recorded at the end of a four day transect survey with two days dedicated to each of the habitat types (Table 2). The most diverse avian family was the Estrildidae family with nine (9) avian species, followed by Columbidae with six (6), while Falconidae, Nectriniidae, and Turdidae families had a record of four (4) species each. Five families (Ardeidae, Malaconotidae, Ploceidae, Sylviidae, Sturnidae) and five families (Accipitridae, Bucerotidae, Capitonidae, Viduade and Psittacidae) followed with three (3) and (2) species respectively. However, 17 families were each represented by a single species (Table 1).

Laughing Dove *Streptopelia senegalensis* was the most abundant bird species with a total of 96 individuals sited in both habitats. Cattle egret *Bulbus ibis* and Vinaceous dove *Streptopelia vinacea* followed with 46 and 41 individuals respectively.

Jaccard/ Tanimoto coefficient of similarity revealed that the two habitats differed in species composition with a percentage difference of 33.3 %. Jaccard/Tanimoto

coefficient was 0.6666 implying that the two habitats were 66.7 % similar in avian species composition. A total of 65 of the 69 species were recorded in the degraded savannah habitat (DS), while 50 species were recorded in the Human inhabited habitat (HI). Interestingly 19 and 4 species were unique to degraded savannah and Human occupied habitats respectively. However, 46 species were common to both habitats.

Shannon Weiner Diversity Index for Human occupied habitat was 1.56 with an effective number of diversity (true diversity) of 4.77. This was almost the same for degraded savannah with 1.67 and 5.32 for SWI and effective number of species respectively.

Investigations to determine the most common feeding guild in the study area revealed that 21 species were frugivorous, while 18 and 16 species were insectivorous and granivorous respectively (Fig. 2).

Table.1: Distribution of avian species across the 32 families recorded in the study area

S/n	Families	Number of species	Families	Number of species
1	Accipitridae	2	Malaconidae	3
2	Alcedinidae	1	Musophagidae	1
3	Ardeidae	3	Nectriniidae	4
4	Bucerotidae	2	Oriolidae	1
5	Capitonidae	2	Paridae	1
6	Charadriidae	1	Passeridae	1
7	Ciconiidae	1	Phasiantidae	1
8	Cisticolidae	1	Picidae	1
9	Columbidae	6	Ploceidae	3
10	Coraciidae	1	Psittacidae	2
11	Corvidae	1	Pyconotidae	1
12	Cuculidae	1	Silviidae	3
13	Estrildidae	9	Sturnidae	3
14	Falconidae	4	Turdidae	4
15	Hirundiniidae	1	Viduadidae	2
16	Laniidae	1	Zosteropidae	1

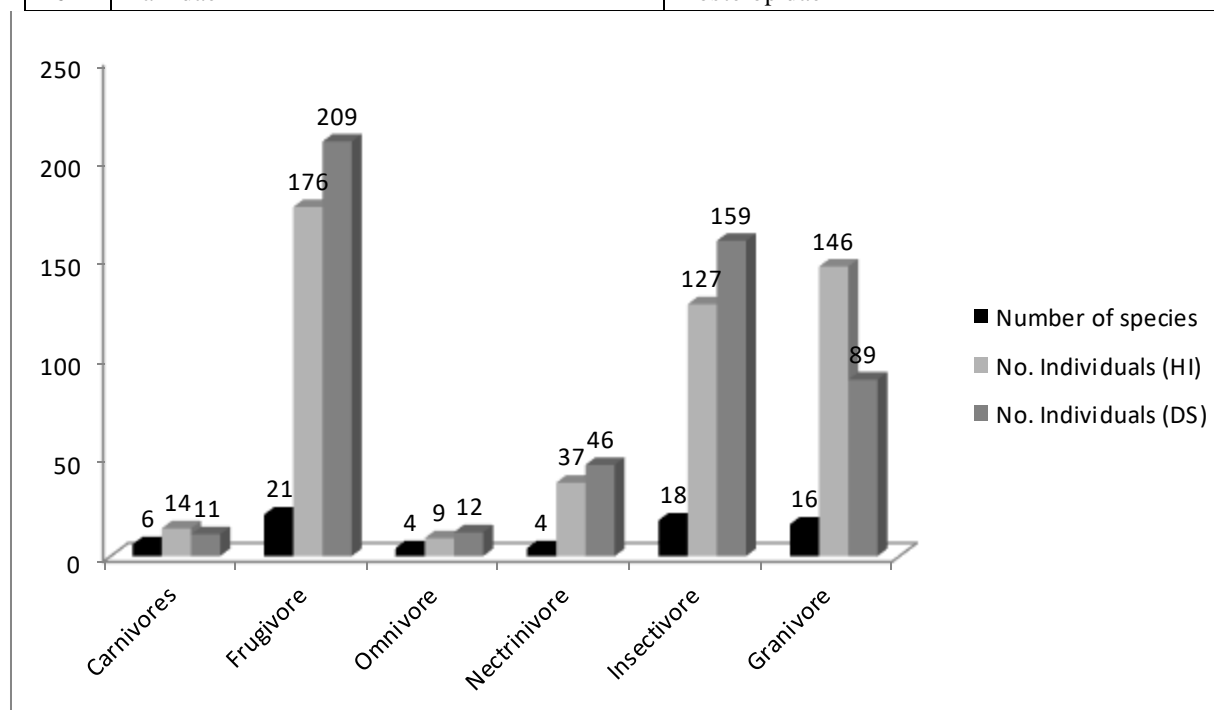


Fig.2: Distribution and abundance of avian species across feeding guilds between the two habitats; HI = Human inhabited, DS = Degraded savannah).

Table.2: Checklist of avian species of the Federal College of Education (Technical) Gombe, Gombe State. √ = present, - = absent

S/N	Species	Scientific name	Family	Human Inhabited	Degraded Savannah	Feeding Guild
1	Cattle Egret	<i>Bulbus ibis</i>	Ardeidae	√	√	Insectivore
2	Black headed heron	<i>Ardeame lanocephala</i>	Ardeidae	-	√	Insectivore
3	Grey heron	<i>Ardea cinerea</i>	Ardeidae	-	√	Insectivore
4	Abdim stork	<i>Ciconia abdimii</i>	Ciconiidae	√	√	Insectivore
5	Black headed lapwing	<i>Vanellus tetus</i>	Charadriidae	√	√	Insectivore
6	Black shouldered kite	<i>Elanus caeruleus</i>	Accipitridae	√	√	Carnivore
7	Shikira	<i>Accipiter badius</i>	Accipitridae	√	√	Carnivore
8	Grey Kestrel	<i>Falco ardosiaceus</i>	Falconidae	√	√	Carnivore
9	Lanner falcon	<i>Falco biarmicus</i>	Falconidae	√	√	Carnivore
10	Fox Kestrel	<i>Falco alopex</i>	Falconidae	√	√	Carnivore
11	Common Kestrel	<i>Falco tinnunculus</i>	Falconidae	√	√	Carnivore
12	Double spur francolin	<i>Francolinus bicalcaratus</i>	Phasianidae	√	√	Omnivore
13	Black billed wood dove	<i>Turtur abyssinicus</i>	Columbidae	√	√	Frugivore
14	African Mourning dove	<i>Streptopelia deceptiens</i>	Columbidae	-	√	Frugivore
15	Laughing Dove	<i>Streptopelia senegalensis</i>	Columbidae	-	√	Frugivore
16	Vinaceous Dove	<i>Streptopelia vinacea</i>	Columbidae	√	√	Frugivore
17	Bruce's Green Pigeon	<i>Treron waalia</i>	Columbidae	√	√	Frugivore
18	Speckled pigeon	<i>Columba guinea</i>	Columbidae	√	√	Frugivore
19	Rose ringed parakeet	<i>Psittacula krameri</i>	Psittacidae	-	√	Frugivore
20	Senegal parrot	<i>Poicephalus senegalus</i>	Psittacidae	√	√	Frugivore
21	Abyssinian roller	<i>Coracias abyssinicus</i>	Coraciidae	√	√	Insectivore
22	African Grey hornbill	<i>Tockus nasatus</i>	Bucerotidae	-	√	Frugivore
23	Red billed hornbill	<i>Tockus erythrorhynchus</i>	Bucerotidae	-	√	Frugivore
24	Bearded barbet	<i>Lybius dubius</i>	Capitonidae	√	√	Frugivore
25	Yellow fronted tinker bird	<i>Pogoniulus chrysoconus</i>	Capitonidae	√	√	Frugivore
26	Cardinal Woodpecker	<i>Dendropicos poecilolaemus</i>	Picidae	√	√	Frugivore
27	Ethiopian Swallow	<i>Hirundo aethiopica</i>	Hirundinidae	√	√	Insectivore
28	Common Bulbul	<i>Pycnonotus barbatus</i>	Pycnonotidae	√	√	Insectivore
29	African Thrush	<i>Turdus pelios</i>	Turdidae	√	√	Frugivore
30	Cliff chat	<i>Myrmecocichla cinnamomeiventris</i>	Turdidae	-	√	Frugivore
31	Northern Ant eater chat	<i>Myrmecocichla aethiops</i>	Turdidae	√	√	Insectivore
32	White Fronted black chat	<i>Myrmecocichla albifrons</i>	Turdidae	√	√	Insectivore
33	Senegal Eremomela	<i>Eremomela pussila</i>	Cisticolidae	√	√	Insectivore
34	Garden Warbler	<i>Silvia borin</i>	Silviidae	-	√	Insectivore
35	Grey backed Camaroptera	<i>Camaroptera brachyuran</i>	Silviidae	-	√	Insectivore
36	Tawny Flanked Prinia	<i>Prinia subflava</i>	Silviidae	-	√	Granivore
37	White shouldered black tit	<i>Parus leucomelas guineensis</i>	Paridae	-	√	Granivore
38	Beautiful sunbird	<i>Cinnyris pulchellus</i>	Nectariniidae	-	√	Omnivore
39	Copper Sunbird	<i>Cinnyris cupreus</i>	Nectariniidae	-	√	Nectarivore
40	Scarlet Chested sunbird	<i>Chalcomitra senegalensis</i>	Nectariniidae	√	√	Nectarivore
41	Variable Sunbird	<i>Cinnyris venustus</i>	Nectariniidae	√	√	Nectarivore
42	Yellow White eye	<i>Zosterops senegalensis</i>	Zosteropidae	√	√	Nectarivore
43	Yellow Bill shrike	<i>Corvinella corvina</i>	Laniidae	√	√	Insectivore
44	Black crown tchagra	<i>Tchagra senegalus</i>	Malaconotidae	√	√	Insectivore
45	Tropical boubou	<i>Lanius turatii</i>	Malaconotidae	√	√	Frugivore

46	Yellow crown Gonolek	<i>Lanius barbarus</i>	Malaconotidae	✓	✓	Frugivore
47	Black headed oriole	<i>Oriolus brachyrhynchus</i>	Oriolidae	✓	✓	Frugivore
48	Pied crow	<i>Corvus albus</i>	Corvidae	-	✓	Frugivore
49	Long tail glossy starling	<i>Lamprotonis caudatus</i>	Sturnidae	✓	✓	Omnivore
50	Purple glossy starling	<i>Lamprotornis purpureus</i>	Sturnidae	✓	✓	Granivore
51	Piapiac	<i>Ptilostomus afer</i>	Sturnidae	-	✓	Granivore
52	Northern Grey headed Sparrow	<i>Passer griseus</i>	Passeridae	-	✓	Granivore
53	Bush Petronia	<i>Petronia dentata</i>	Ploceidae	✓	✓	Granivore
54	Little Weaver	<i>Ploceus luteolus</i>	Ploceidae	-	✓	Granivore
55	Village Weaver	<i>Ploceus cucullatus</i>	Ploceidae	✓	-	Granivore
56	African Silver bill	<i>Eudice cantans</i>	Estrildidae	✓	✓	Granivore
57	Bronze Mannikin	<i>Spermetes cucullatus</i>	Estrildidae	✓	✓	Granivore
58	Cinnamon Breasted-Rock Bunting	<i>Emberiza tahapisi</i>	Estrildidae	✓	✓	Granivore
59	Cut throat finch	<i>Amadina fasciata</i>	Estrildidae	✓	✓	Granivore
60	Red billed Fire Finch	<i>Lagonosticta senegala</i>	Estrildidae	-	✓	Granivore
61	Orange cheeked waxbill	<i>Estrilda melpoda</i>	Estrildidae	✓	✓	Granivore
62	Black crown waxbill	<i>Estrilda nonnulacens</i>	Estrildidae	✓	✓	Granivore
63	Lavender waxbill	<i>Estrilda caerules</i>	Estrildidae	✓	✓	Granivore
64	Red Cheeked cordon bleu	<i>Uraeginthus bengalus</i>	Estrildidae	✓	✓	Granivore
65	Western Grey Plantain eater	<i>Crinifer piscator</i>	Musophagidae	✓	✓	Frugivore
66	Senegal Coucal	<i>Centropus senegalensis</i>	Cuculidae	✓	✓	Frugivore
67	Grey Headed Kingfisher	<i>Halcyon malimbica</i>	Alcedinidae	✓	✓	Omnivore
68	Village indigo bird	<i>Vidua chalybeate</i>	Viduidae	✓	-	Granivore
69	Pintail Whydah	<i>Vidua macoura</i>	Viduidae	✓	-	Granivore

IV. DISCUSSION

Many institutions of higher learning are adorned with ornamental as well as exotic and native tree species. Apart from the primary role of aesthetics, trees are biologically crucial in climate moderation, carbon sequestration, and mitigation of run-offs and floods during the rains. In addition plants help in air purification, shade provision/ wind break and reduction in noise pollution (Novak and Dwyer 2007). It is also a fact that plants inadvertently provide primary habitats for a vast number of life forms thereby promoting biodiversity.

Birds are ubiquitous and have learnt to utilize various habitats both natural and human modified (Borow and Demey, 2004), and as such, we tested whether species assemblage will differ between two distinct habitat types; a human occupied and a degraded savannah habitat. Our thinking was predicated on the notion that habitat structure is a major predictor of habitat choice by birds as has been

suggested by some studies (Nsor, 2006; Abalaka and Manu, 2007; Manu et al., 2007; Manu et al., 2010; Dami et al., 2014).

Our record of 69 avian species is in consonance with similar studies, example Agbo et al. (2018) who recorded 60 avian species in a similar landscape in Kaduna, Kaduna state. Moreover, our findings are in tandem with other surveys within the region of Gombe State where the authors reported species richness values similar to our present findings (Nsor and Adang, 2012; Adang et al, 2015a, Adang et al, 2015b). However, the scale of enquiry (survey duration) may be a limiting factor and a major bias if we were to run a comparative analysis of species richness among the various study sites. Nonetheless, our results indicate, a relatively higher species richness compared to previous studies given that the survey was conducted for just four days.

Our quest to determine how well avian species make the best of a human modified and degraded savannah habitats was quite revealing; our results suggest that most of the birds in fact 66.7 % use both habitats freely although their distribution may favor one habitat over the other in terms of abundance. For example, the most abundant bird species Laughing Dove *Streptopelia senegalensis*, Cattle egret *Bulbus ibis* and Vinaceous dove *Streptopelia vinacea* were more abundant in the Human inhabited habitat than in the degraded savannah, alluding to the fact that perhaps becoming use to human presence was an adaptive advantage. However, it is interesting to note the possible interplay of resource distribution, competition, and habitat patchiness in driving certain individuals of some species to forage in specific habitats even at the risk of predation. This is in keeping with the source-sink theory and the meta-population concept (Hanski, 1994, Hanski et al., 1995).

Birds are known to occupy certain feeding guilds, with several species sharing the same food resources. While most studies on resource distribution focused on the spatio-temporal distribution, few have dwelled on the vertical distribution of avian food resources. However in a recent study, Bakam et al (2018) demonstrated how birds utilize resources along a vertical gradient. They authors asserted that the more structurally diverse a habitat is, the more likely it is to support diversity, which is in consonance with the works of Manu (2007). In this study, we recorded 21 frugivorous species occupying various heights in a vertically stratified niche arrangement which keeps them often above their zero elevation foraging counterparts –16 species of granivores, while 18 species of insectivores oscillated between different strata, often spending most of their time on the ground hunting for insects. Omnivorous species on the other hand occupied and fed along a vertical gradient while the birds of prey –6 species of carnivores (raptors) swoop down on their prey from the top stratum where they often perch for hours (Bakam et al., 2018).

This observed partition of resources reduces interspecies competition while facilitating species cooperation. Against this backdrop, it would not be out of place to say that based on the results of this study, that the relatively high level of diversity could be a direct benefit of habitat heterogeneity as reflected in the various feeding guilds highlighted above while also consolidating the notion that vertical stratification of resources is positively associated with avian species diversity and optimizes species richness in concert with other habitat and environmental parameters such as foliage volume and percentage vegetation cover (Karr and Roth, 1971; James and Warner, 1982).

Furthermore, the differences in species composition between the two habitats investigated in this study confirm the notion that a heterogeneous habitat supports more species diversity than a homogeneous one (Abalaka and Manu, 2007; Dami et al., 2014). The human inhabited habitat was found to be dominated by exotic and introduced plant species planted in a homogenous pattern (Pringle et al, 2010). This fact coupled with vehicular and human presence may be one of the reasons why more species were recorded in the degraded savannah habitat than the human inhabited one (Imong, 2007).

Moreover, most bird species are naturally elusive and avoid habitats that do not offer adequate cover; some of these species e.g. Bush Petronia *Petronia dentata*, Senegal Parrot *Poicephalus senegalus*, Tawny flanked Prinia *Prinia subflava*, Grey Backed Camaroptera *Camaroptera brachyuran*, Double spur Francolin *Poicephalus senegalus* etc., were found to occur only in the degraded savannah where some remnant shrubby patches offer cover. However because birds are highly mobile apart from the flightless ones, they often go beyond their comfort zones to human inhabited areas especially when the habitats offer some movement “corridors” or safe patches to facilitate movement between distinct habitats (Noss, 1991). This was the case with some species that are seldom seen in isolated human dominated landscape. Some of these human evading and habitat sensitive species (e.g. Yellow crown Gonolek *Laniarus barbarous*, Black crown Tchagra *Tchagra senegalus* and the Red-billed Hornbill *Lagonosticta senegala* were seen freely foraging in the human inhabited habitat in this study.

The aforementioned species could easily forage in both habitats because there was really no clear demarcation between the two habitats. Moreover, some portions of the human inhabited habitats tapered nicely into the degraded savannah contiguously (Noss, 1991). This observation emphasizes the need for landscape experts and environmentalist to design campuses and other public facilities such that natural patches of indigenous flora will be interspersed with buildings and introduced flora. This will go a long way to encourage diurnal movements of avian species between patches and on a broader scale more biodiversity.

V. CONCLUSION

The study identified certain anthropogenic activities that may be detrimental to avian species wellbeing and abundance in the study area if urgent actions are not taken. These include but not limited to; indiscriminate and

unregulated extraction of fuel wood, excessive conversion of remnant woodland to agricultural fields, unsustainable extraction of plants of ethno-botanical importance, unregulated movement of pedestrian and poachers into the college through multiple entry and exit routes.

We urge the college management to as a matter of urgency block all unauthorized entry and exit routes to check unsustainable harvest of fuel wood. More native tree species should be reintroduced to mute the invasive effect of exotic species and restore networks of interactions that have been broken with the exit of native key stone tree species. The campus has potential to be a major refuge for birds and other smaller invertebrate species if all stakeholders rejig their commitment to nature and their stewardship obligation to biodiversity.

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